CIRCULAR No. 38 SEPTEMBER, 1928
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

# AN APPARATUS FOR ADDING GYPSUM TO IRRIGATION WATER

By C. S. Scofield, *Principal Agriculturist in Charge*, and Elmer W. Knight, *Assistant Agronomist, Office of Western Irrigation Agriculture, Bureau of Plant Industry*

CONTENTS



## INTRODUCTION

There are many areas of irrigated land in the western United States where the physical condition of the soil is such that it does not absorb water readily. These areas are known locally as hard spots or hard lands. This condition is the result of reactions of base exchange between the soil and the salts in the soil solution by which sodium from the soil solution enters into chemical combination with the soil in exchange for calcium, which in turn passes from combination with the soil into the solution. These reactions of base exchange take place as the result of changes in equilibrium between the bases in the soil solution. When the equilibrium between the bases or cations in the solution changes, as by an addition of sodium salts, the exchange is in the direction of combining sodium with the soil and of releasing calcium from it. The reactions diminish and finally cease when equilibrium is reestablished as by the absorption of sodium by the soil and the release of an equivalent of calcium into the solution.

Experience has shown that the use of irrigation water containing substantially more sodium than calcium has an injurious effect on the physical condition of the soil. In other words, soft water makes hard land and hard water makes soft land.[1] Many well waters used for irrigation as well as some surface waters contain so much more sodium than calcium that their use results in reducing the permeability of the soil and ultimately its productivity.

Where it is desired to improve the physical condition of the soil for the purpose of obtaining better penetration of irrigation water, it has been found that the application of gypsum is beneficial. When gypsum is applied to the soil it dissolves slowly in the soil solution, and the consequent increase of the calcium content of that solution tends to retard the absorption of sodium by the soil or even to replace some of the combined sodium.

---

[1] Scofield, C. S., and Headley, F. B. QUALITY OF IRRIGATION WATER IN RELATION TO LAND RECLAMATION. Jour. Agr. Research 21: 265–278. 1921.

1680—28

The application of gypsum to hard or puddled irrigated soils to improve their physical conditions is a well-established practice. Ordinarily dry, finely pulverized gypsum is scattered over the soil and plowed under or harrowed in. Sometimes it is applied as a supplement to barnyard manure, the two being spread together and worked into the soil. Dry gypsum dissolves rather slowly because it is not very soluble and the moisture content of the surface soil is very low most of the time. Furthermore, part of the gypsum may become incorporated in lumps of earth and remain inert for a long time, and part of it may be blown away. For these reasons it seemed desirable to develop a method of applying gypsum in solution in irrigation water. By such a method it should be possible to avoid loss of material, to obtain better distribution through the root zone, and to hasten the reactions in the soil.

Attempts to get gypsum into solution by pouring the dry material into an irrigation stream gave unsatisfactory results. It was found necessary to devise an apparatus with which the material could be dusted into the water and the water then stirred vigorously to expedite solution. To permit wide use it seemed desirable that the apparatus should be relatively inexpensive, that its operation should be automatic, and that its installation should not involve loss of head in the irrigation ditch. With these requirements and limitations in mind, the junior writer constructed an experimental machine in the fall of 1925. It was installed on one of the farm ditches of the Newlands Field Station, Fallon, Nev., and was in regular operation throughout the irrigation seasons of 1926 and 1927.

## DESCRIPTION OF THE GYPSUM DISTRIBUTOR

The machine (fig. 1), which is made chiefly of galvanized sheet iron, consists of four main parts: A hopper (*a*) to contain the gypsum; a revolving feeding device (*b*); a submerged stirring device (*c*); and a paddle wheel (*d*) driven by the irrigation stream to actuate the feeding and stirring devices. The hopper is 30 inches long, 18 inches wide, and 30 inches high, with the bottom sloping from the longer sides to a narrow slit at the center. It has a loose-fitting metal cover. The revolving feeding device is set just above the narrow opening in the bottom of the hopper. It is a slender metal drive shaft supported at either end in bicycle bearings and carrying a sprocket wheel on one end. Attached to this drive shaft inside the hopper are two strips of metal that push the gypsum through the opening in the bottom of the hopper as the feed shaft revolves. There is a supplemental feeding device (fig. 1, A) which is a counterbalanced hammer to tap the side of the hopper with each revolution of the paddle wheel and thus keep the gypsum from packing and bridging above the revolving feeder. The stirring device includes a perforated cylinder of galvanized iron, 15 inches in diameter and 30 inches long, attached to the bottom of the hopper. Inside this cylinder is a revolving paddle the two blades of which extend the full length of the cylinder. These blades are also of galvanized iron, much perforated, to obtain a maximum stirring effect with a minimum of friction. The cylinder with its internal paddle is partially or completely submerged in the irrigation stream when the apparatus is in operation.

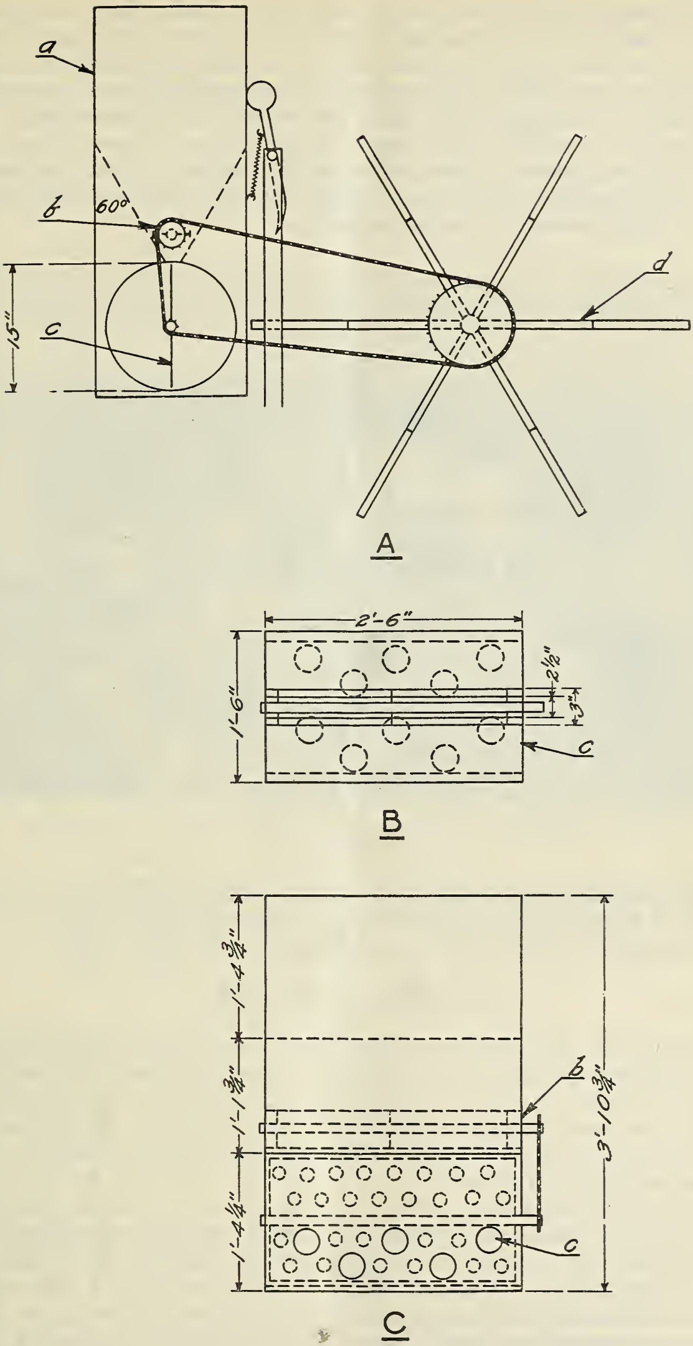


Fig. 1.—Dimensions and arrangement of parts of the gypsum distributor. A.—Side view: *a*, Hopper to contain the gypsum; *b*, revolving feeding device; *c*, submerged stirring device; *d*, paddle wheel. B.—Top view: *c*, Submerged stirring device. C.—Front view: *b*, Revolving feeding device; *c*, submerged stirring device

The external paddle wheel which actuates the feeding and stirring devices is constructed from two metal wheels such as those of a hay rake or a manure spreader, the outer rim and each alternate spoke having been removed. These wheels were attached to a drive shaft set in roller bearings with a sprocket wheel at one outer end. The blades of the paddle wheel were made of galvanized sheet iron attached to the wheel spokes as shown in Figure 2. The sprocket of the external paddle wheels was connected with those of the feeding and stirring devices by a bicycle chain.

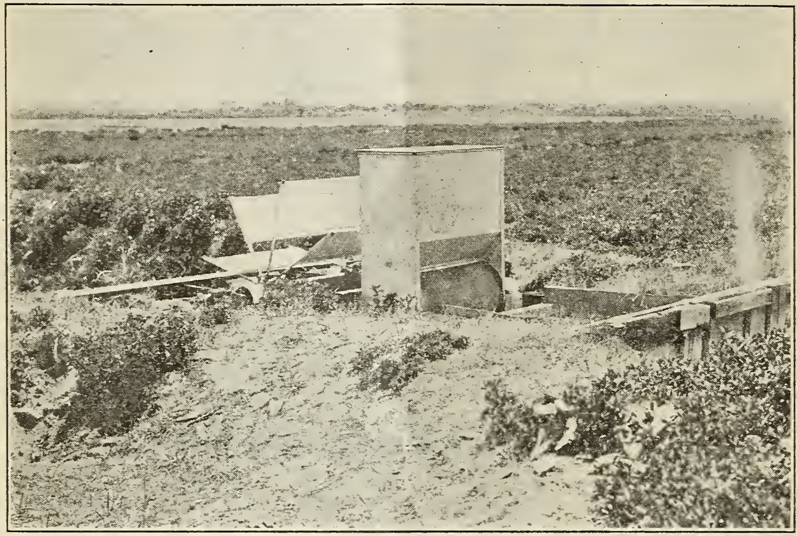

FIG. 2.—Gypsum distributor installed on a farm ditch at the Newlands Field Station, Fallon, Nev.

It was found possible to operate this machine with an irrigation stream of 3 to 5 second-feet, without appreciable loss of head and with a rate of feed of 5 to 6 pounds of gypsum per minute.

## THE RESULTS OBTAINED

The gypsum distributor as described was installed and operated experimentally in the fall of 1925 on one of the farm ditches at the Newlands Field Station. It worked satisfactorily. It seemed desirable, however, to make a series of tests with it to determine how much gypsum could be fed into the irrigation stream and how much of it passed into solution.

During the summer of 1926 five test runs were made. In these tests the observations included the volume of the irrigation stream in cubic feet per second, the length of time the machine was operated, the quantity of gypsum fed into the stream, and the calcium content of the irrigation stream above and below the machine. From these measurements estimates were made as to the proportion of the gypsum used that was carried to the field in solution, the quantity fed per acre-foot of water, and the quantity applied in solution

to each acre irrigated. The tests for the season when summarized showed that for each acre of land irrigated there had been applied 18 inches in depth of water into which had been fed 967 pounds of gypsum and that 357 pounds of this was found to be in solution. This shows that about 37 per cent of the gypsum fed into the irrigation stream was in solution a short distance below the machine and before the water was spread over the land. It seems fair to assume that a substantial part of the undissolved material was carried to the land and that much of it may have passed into solution before the irrigation water was lost by evaporation.

During the season of 1927 six tests were made with the gypsum distributor at the Newlands Field Station. The ditch on which it was installed served a tract of 2.1 acres. The details of these tests together with some of the estimated results are given in Table 1. A summary of these tests shows that for each acre there was applied 22.26 acre-inches of water into which was fed 1,988 pounds of gypsum, and that 1,202 pounds of this was found to be in solution before it reached the land. In other words, approximately 60 per cent of the gypsum used had passed immediately into solution. The better results obtained in 1927 as compared with those of 1926 appear to have been due to adjustments in connection with feeding the gypsum into the water and the subsequent stirring.

TABLE 1.—*Data on the performance of a gypsum distributor on 2.1 acres of irrigated land at Newlands Field Station, Fallon, Nev., in 1927*

| Runs | | Rate | Depth of water applied | Amount of water | | Gypsum [1] | | | | | | Calcium content below distributor [2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | In solution | | | | |
| Date | Time | | | Acre-feet | Million pounds | Fed | Per acre-foot | Parts per million | Per acre-foot | Per acre | Unaccounted for | |
| | *Min.* | *Sec.-ft.* | *Ins.* | | | *Lbs.* | *Lbs.* | | *Lbs.* | *Lbs.* | *Lbs.* | *Per ct.* |
| June 5 | 130 | 4.35 | 4.45 | 0.78 | 2.117 | 736 | 943 | 310 | 841 | 312 | 80 | 4.6 |
| June 27 | 150 | 3.23 | 3.83 | .67 | 1.814 | 736 | 1,103 | 292 | 794 | 253 | 206 | 4.4 |
| July 13 | 90 | 4.63 | 3.25 | .57 | 1.560 | 736 | 1,282 | 236 | 642 | 174 | 367 | 3.75 |
| July 26 | 150 | 2.70 | 3.18 | .56 | 1.516 | 736 | 1,321 | 301 | 817 | 218 | 281 | 4.5 |
| Aug. 18 | 200 | 2.26 | 3.55 | .62 | 1.692 | 736 | 1,183 | 146 | 397 | 117 | 489 | 2.7 |
| Sept. 9 | 135 | 3.77 | 4.0 | .70 | 1.905 | 500 | 714 | 142 | 385 | 128 | 231 | 2.65 |
| All dates | | | 22.26 | 3.90 | 10.604 | 4,180 | | 1,427 | | | 1,654 | |

[1] $CaSO_4+2H_2O$.
[2] Includes the calcium originally in the water, which was approximately r 1.0, or 20 parts per million.

It is believed that this method of applying gypsum to irrigated land, or more precisely this method of "hardening" irrigation water, may be usefully employed in a number of places in the irrigated region. It worked well at the Newlands Field Station where the distribution of water is through a gravity system over land that is nearly level and the ditch velocities are low. It should give much better results where it could be installed at the outfall of a pump or at a drop in a ditch serving sloping land. It seems obvious that where the conditions of soil or of irrigation water are such as to indicate the need of gypsum, this can be supplied more economically and efficiently by dissolving the gypsum in the irrigation water than by applying it in the dry form to the soil.

## ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

September 10, 1928

| | |
|---|---|
| *Secretary of Agriculture* | W. M. JARDINE. |
| *Assistant Secretary* | R. W. DUNLAP. |
| *Director of Scientific Work* | A. F. WOODS. |
| *Director of Regulatory Work* | WALTER G. CAMPBELL. |
| *Director of Extension* | C. W. WARBURTON. |
| *Director of Personnel and Business Administration* | W. W. STOCKBERGER. |
| *Director of Information* | NELSON ANTRIM CRAWFORD. |
| *Solicitor* | R. W. WILLIAMS. |
| *Weather Bureau* | CHARLES F. MARVIN, *Chief.* |
| *Bureau of Animal Industry* | JOHN R. MOHLER, *Chief.* |
| *Bureau of Dairy Industry* | O. E. REED, *Chief.* |
| *Bureau of Plant Industry* | WILLIAM A. TAYLOR, *Chief.* |
| *Forest Service* | R. Y. STUART, *Chief.* |
| *Bureau of Chemistry and Soils* | H. G. KNIGHT, *Chief.* |
| *Bureau of Entomology* | C. L. MARLATT, *Chief.* |
| *Bureau of Biological Survey* | PAUL G. REDINGTON, *Chief.* |
| *Bureau of Public Roads* | THOMAS H. MACDONALD, *Chief.* |
| *Bureau of Agricultural Economics* | NILS A. OLSEN, *Chief.* |
| *Bureau of Home Economics* | LOUISE STANLEY, *Chief.* |
| *Plant Quarantine and Control Administration* | C. L. MARLATT, *Chief.* |
| *Grain Futures Administration* | J. W. T. DUVEL, *Chief.* |
| *Food, Drug, and Insecticide Administration* | WALTER G. CAMPBELL, *Director of Regulatory Work, in Charge.* |
| *Office of Experiment Stations* | E. W. ALLEN, *Chief.* |
| *Office of Cooperative Extension Work* | C. B. SMITH, *Chief.* |
| *Library* | CLARIBEL R. BARNETT, *Librarian.* |

This circular is a contribution from

| | |
|---|---|
| *Bureau of Plant Industry* | WILLIAM A. TAYLOR, *Chief.* |
| *Office of Western Irrigation Agriculture* | C. S. SCOFIELD, *Principal Agriculturist, in Charge.* |



ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
5 CENTS PER COPY
▽